EPA United States
Environmental Protection
Agency

AERMINUTE User's Guide

AERMINUTE User's Guide

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Assessment Division
Air Quality Modeling Group
Research Triangle Park, North Carolina

Preface

This document provides a description of AERMINUTE, a pre-processor to AERMET to read 1-minute and optionally, 5-minute ASOS data to calculate hourly average winds for input into AERMET. Included in this document are descriptions of inputs, processing methodology, and outputs.

Contents

Figures

Tables

1. Purpose

Surface meteorological data collected by the National Weather Service (NWS) and Federal Aviation Administration (FAA) are often used as the source of input meteorological data for AERMOD (EPA, 2010a). A potential concern related to the use of NWS meteorological data for dispersion modeling is the often high incidence of calms and variable wind conditions reported for the Automated Surface Observing Stations (ASOS) in use at most NWS stations since the mid-1990's. In the METAR coding used to report surface observations beginning July 1996, a calm wind is defined as a wind speed less than 3 knots and is assigned a value of 0 knots. The METAR code also introduced the variable wind observation that may include wind speeds up to 6 knots, but the wind direction is reported as missing, if the wind direction varies more than 60 degrees during the 2-minute averaging period for the observation. The AERMOD model currently cannot simulate dispersion under calm or missing wind conditions. To reduce the number of calms and missing winds in the surface data, archived 1-minute winds for the ASOS stations can be used to calculate hourly average wind speed and directions, which are used to supplement the standard archive of hourly observed winds processed in AERMET (EPA, 2010b). Beginning with version 15272, AERMINUTE will also read in 5-minute ASOS data to supplement the 1-minute data when 1-minute data is missing. The 5-minute data consists of the 2-minute wind speeds reported every 5-minutes. The impetus for including the 5-minute data files is due to 253 stations across the U.S. missing 1-minute data files for June through December of 2013. These stations did have 5-minute data files however that could be used to supplement the missing data. A list and map of the 253 stations can be found in Appendix B of this document.

2. Changes to AERMINUTE

The original version of AERMINUTE is version 11059. Following is a list of changes with each subsequent version.

2.1 Version 11325

1. Modified subroutine CHECKWIND to adjust quality control flags 3, 4, and 5 when checking the wind data line format. Flag 3 was modified to better check for four digit character strings that may indicate a possible time. In version 11059 of AERMINUTE, any four digit string was considered a possible time. In version 11325, the string is only considered a possible time if the entire four digit string is a complete integer string, i.e. 1105 would be a possible time but not 110503. If a possible time is found flag 3 is set to one, otherwise flag 3 is zero. Flag 4 previously checked for a 'M', 'N', or 'D' in column 39. Flag 4 now checks for a non-blank character in column 30. If column 30 contains a non-blank character, then flag 4 is set to one. Otherwise, flag 4 is zero. Flag 5 as modified to look for any non-blank character in column 67 of the data line. If a non-blank character is found in column 67 flag 5 is set to one, otherwise flag 5 is zero. For any of the three flags, if a value is one, the record is considered suspicious and not used in hourly averaging. The record is output to check_records.dat.

2.2 Version 14237

1. Modified subroutine CHECKWIND to adjust quality control flags 6 through 9. Flags 6 through 9 were modified to account a change in the format of the 6405 1-minute data files roughly beginning with year 2014 files. Flag 6 (2-minute wind direction) now checks columns 70-74, flag 7 (2-minute wind speed) checks columns 76-79, flag 8(5-second gust direction) checks columns 82-84 and flag 9 (5-second gust speed) checks for columns 87-89. For these flags, if there is a number in any of those columns, the respective flag is set to 0, otherwise the flag is set to 1. These changes allow AERMINUTE to work with pre 2014 and 2014 and new files.
2. Modified subroutine CHECKWIND to create a new flag 10. Flag 10 checks columns 64-68 for non-blank characters. If a non-blank character is found flag 10 is set to 1, otherwise it is set to 0.
3. Modified subroutine CHECKWIND to create a new flag 11. Flag 11 checks column 90 for a non-blank character. If a non-blank character is found, flag 11 is set to 1, otherwise it is set to 0.
4. Modified subroutine CHECKWIND to make the previous versions of flags 10 and 11 to 12 and 13 respectively.
5. Modified subroutine CHECKWIND to check for the number of fields in columns 67-90 if the record passes the strict quality control check, all flags are zero. The number of fields should be four, representing 2-minute wind direction and speed and 5-second gust direction and speed. If the number of fields is not equal to 4 then flag 12 is set 1 and flag 13 is set to the number of fields. If the number of fields is equal to 4 then flag 12 is set to 0 and flag 13 is set to 9.
6. Modified subroutine CHECKWIND to increase size of variables aflag and iflag1 from 11 to 13
7. Modified module MAIN1 reset variable flagcounts from size 12 to 14.
8. Modified subroutine READONE, modified variable flagstr from size 12 to 14 and included descriptions of modified flags 6-9 and new flags 10 and 11. Also the format statement for the counts of records was modified to left justify the text and right justify the counts.
9. Modified subroutine READLINE to increase length of variable aflag from 11 to 13 to accommodate new flags.

2.3 Version 14337

1. Modified subroutine CHECKWIND to remove the check on column 67 for non-blank character and columns 64-68 for non-blank characters.
2. Flags 6-12 were renumbered accordingly, flags 6-9 became flags 5-8 and flags 11 and 12 became flags 9 and 10.
3. Modified subroutine CHECKWIND to search columns 68-90 for non-numeric columns for flag 1. The check was originally columns 67-90.
4. Modified subroutine CHECKWIND to decrease the size of variables aflag and iflag1 from 13 to 11.
5. Modified module MAIN1 to reset variable flagcounts from size 14 to 12.

6. Modified subroutine READONE to reset variable flagstr from size 14 to 12 and included descriptions of modified flags.
7. Modified subroutine READLINE to decrease length of variable aflag from 13 to 11 to accommodate new flags.

2.4 Version 15272

1. Modified subroutine USERINP to add optional data section for 5-minute ASOS data files (DSI-6401 format).
2. Modified subroutine USERINP to allow for no 1-minute data file listing as long as optional 5-minute data files are listed.
3. Modified subroutine USERINP to allow for optional output files, SUB5FILE and 1_5_FILE.
4. Modified subroutine CHECKFILES to perform QA on 1-minute or optional 5-minute data filenames.
5. Added subroutines READFIVE, READ5, and CHECKWIND5 to read and QA 5-minute data files.
6. Added subroutine CHECKWBAN to check WBAN number for non-numeric characters for 1-minute and 5-minute data files.
7. Added subroutine SUB5 to substitute missing 1-minute data values with corresponding 5-minute data values.
8. Modified subroutine WRITEOUT to include 5-minute data summaries for summary file and output file.
9. Modified subroutine MINMAXONE to include source of minimum and maximum 2-minute winds, i.e. 1-minute or 5-minute data file.
10. Modified subroutine HOURLYMINMAX to include source of data (1-minute or 5-minute) for hourly minimum and maximum wind speeds and directions.

3. Obtaining ASOS wind data

Recently, the National Climatic Data Center (NCDC) began archiving the 2-minute average wind speeds for each minute of the hour for most ASOS stations for public access. These 2-minute values have not been subjected to the METAR coding for calm and variable winds, but have also been subjected to only limited quality control measures. However, the 2-minute winds listed in the 5-minute files have been subjected to the METAR coding for calm and variable winds. The 1-minute ASOS wind data consists of running 2-minute average winds, reported every minute, for commissioned ASOS stations. The 1-minute ASOS wind data can be obtained without cost through the National Climatic Data Center (NCDC) website at ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/ and the 5-minute data can be obtained at ftp://ftp.ncdc.noaa.gov/pub/data/asos-fivemin/

The 1-minute ASOS winds are in the DSI-6405 format (sub-directories with 6405 as the first four characters in the 1-minute ftp directory listed above) and the 5-minute winds are in the DSI-6401 format (sub-directories 6401 as the first four characters in the 5-minute data ftp directory listed above). For both types of data, for each station and year, files are available in monthly

blocks, i.e. one file per month for a station. Files are generally named
640Z0XXXXYYYYMM.dat where Z is 1 for 6401 (5-minute data) or 6405 (1-minute data),
XXXX is the four-character station call sign, and YYYY and MM are the 4-digit year and 2-digit
month. Example 1-minute and 5-minute filenames for Raleigh-Durham for January 2003 are
'64050KRDU200301.dat' and '64010KRDU200301.dat' respectively. First-order stations'
archives generally begin with data for 2000 for both datasets. Other stations' archives generally
start in March 2005 for both datasets.

The file format of the 1-minute files can be found at
http://www1.ncdc.noaa.gov/pub/data/documentlibrary/tddoc/td6405.pdf and the format for the 5-
minute files (post 1998) can be found at
http://www1.ncdc.noaa.gov/pub/data/documentlibrary/tddoc/td6401b.pdf

The general format of a 1-minute file and variable descriptions is shown in Figure 1 and a 5-
minute file is shown in Figure 2.

13874KATL	ATL2003010100000500	0.059 N		0.118 N	135	10	125	10	09R60+
13874KATL	ATL2003010100010501	0.058 N		0.118 N	136	9	131	11	09R60+
13874KATL	ATL2003010100020502	0.058 N		0.118 N	141	9	143	11	09R60+
13874KATL	ATL2003010100030503	0.056 N		0.118 N	148	10	164	13	09R60+
13874KATL	ATL2003010100040504	0.054 N		0.119 N	154	11	151	13	09R60+
13874KATL	ATL2003010100050505	0.054 N		0.120 N	157	11	163	13	09R60+
13874KATL	ATL2003010100060506	0.052 N		0.117 N	160	11	166	13	09R60+
13874KATL	ATL2003010100070507	0.053 N		0.117 N	156	10	154	12	09R60+

Variable	Columns
Station WBAN Number	1-5
4-letter station call sign (with leading K or P in most cases)	6-9
3-letter station call sign (without leading character)	11-13
4-digit year in local standard time (LST)	14-17
2-digit month in LST	18-19
2-digit day in LST	20-21
2-digit hour (00-23) in LST	22-23
2-digit minute (00-59) in LST	24-25
2-digit hour (00-23) in Universal Time Coordinate (UTC)	26-27
2-digit minute (00-59) in UTC	28-29
Visible extinction coefficient at first sensor (N=night, D=day, M=missing)	31-41*
Visible extinction coefficient at second sensor (N=night, D=day, M=missing)	Varies
2-minute average wind direction (deg)	67-74*
2-minute average wind speed (knots)	75-79*
Maximum 5-second wind speed direction (deg)	80-84*
Maximum 5-second wind speed (knots)	85-89*
Runway visual range (hundreds of feet)	92-97*
*Column placement is not always fixed for these variables. Ranges are based on visual inspection of files during program testing.	

Figure 1. General format of an ASOS 1-minute file.

As can be seen in the variable descriptions in Figure 1, the station information (WBAN and call
signs) and dates are in fixed formats while the wind data are not always in the same columns.
AERMINUTE takes the wind data format variability into consideration when reading the wind

data variables during file processing and looks for ranges of columns for the data variables. Also, as discussed in more detail in Section 5.2 and Appendix A, the 1-minute ASOS data files often records with "garbled" data that do not follow any clear format. For the 5-minute files, the files appear to be in a more consistent format. Note in Figure 2, winds reported as '00000KT' have been subjected to the METAR calms coding and winds starting with 'VRB' have been subjected to the METAR variable wind coding.

```
03032K6R6 6R620050303044010103/03/05 04:40:31  5-MIN K6R6 031040Z AUTO 00000KT 07/04 A2999 2260 82 1900 000/00 RMK AO2 PWINO TSNO
03032K6R6 6R620050303044510103/03/05 04:45:31  5-MIN K6R6 031045Z AUTO 30003KT 07/04 A2999 2260 82 1900 300/03 RMK AO2 PWINO TSNO
03032K6R6 6R620050303045011803/03/05 04:50:31  5-MIN K6R6 031050Z AUTO 29003KT 07/04 A2999 2260 82 1900 280/03 RMK AO2 SLP139 T00720044 PWINO TSNO
03032K6R6 6R620050303045510103/03/05 04:55:31  5-MIN K6R6 031055Z AUTO 29004KT 07/04 A2999 2260 82 1900 290/04 RMK AO2 PWINO TSNO
03032K6R6 6R620050303050010103/03/05 05:00:31  5-MIN K6R6 031100Z AUTO 29005KT 07/04 A3000 2250 86 1800 290/05 RMK AO2 PWINO TSNO
03032K6R6 6R620050303050510103/03/05 05:05:31  5-MIN K6R6 031105Z AUTO 28006KT 07/04 A3000 2250 82 1800 270/06 RMK AO2 PWINO TSNO
03032K6R6 6R620050303051010103/03/05 05:10:31  5-MIN K6R6 031110Z AUTO 29007KT 06/04 A3000 2250 86 1800 290/07 RMK AO2 PWINO TSNO
03032K6R6 6R620050303111010103/03/05 11:10:31  5-MIN K6R6 031710Z AUTO VRB04KT 14/08 A3009 2160 64 2600 VRB/04 RMK AO2 PWINO TSNO
03032K6R6 6R620050303180010803/03/05 18:00:31  5-MIN K6R6 040000Z AUTO 13012G19KT 19/07 A2995 2290 44  3400 130/12G19 RMK AO2 PWINO TSNO
```

Variable	Columns
Station WBAN Number	1-5
4-letter station call sign (with leading K or P in most cases)	6-9
3-letter station call sign (without leading character)	11-13
4-digit year in local standard time (LST)	14-17
2-digit month in LST	18-19
2-digit day in LST	20-21
2-digit hour (00-23) in LST	22-23
2-digit minute at 5-minute interval (00-55) in LST	24-25
Record length starting at column 29	26-28
Date in LST (MM/DD/YY)	29-36
Tim in LST (HH:MM:SS)	38-45
Data type (always "5-min")	48-52
4-letter station call sign (with leading K in most cases)	54-57
Date and time in UTC (ddhhmmZ)	59-65
Observation type (only present when in auto mode = 'AUTO')	67-70
2-minute average wind direction in tens of degrees (degrees/10)	67-68 (if 'AUTO' not present), 72-73 (if 'AUTO' present)
2-minute average wind speed (knots)	69-71 (if 'AUTO' not present), 74-76 (if 'AUTO' present)

Figure 2. General format of an ASOS 5-minute file.

4. Processing and hourly averaging

4.1 User inputs

The user must create a file that contains information that controls the processing in AERMINUTE, including several pieces of information about the station as well as the of the 1-minute data files and optional 5-minute files. The user is prompted for the name of input file (Figure 3). The structure and keywords of the file are shown in

Figure 4. In the input file, lines that start with '**' in the first two columns are comment lines and are not processed by AERMINUTE. Each section of information is described below.
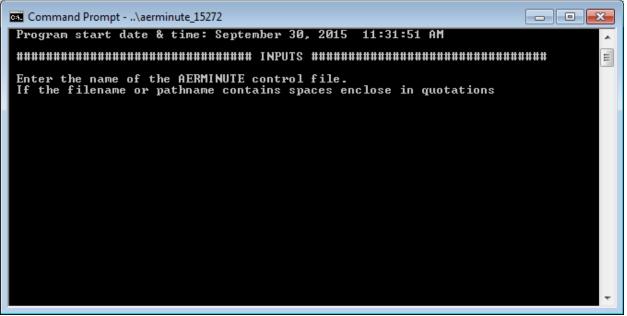

Figure 3. Initial prompt of name of AERMINUTE control file.

```
STARTEND  start_month start_year end_month end_year

IFWGROUP  Status  comm_month comm_day comm_year

DATAFILE STARTING
1-minute data file list
DATAFILE FINISHED

DAT5FILE STARTING            (Optional)
5-minute data file list
DAT5FILE FINISHED

SURFDATA STARTING            (Optional)
Surface files list
SURFDATA FINISHED

OUTFILES STARTING
HOURFILE name
SUMMFILE name                (Optional)
COMPFILE name                (Optional)
1_5_FILE name                (Optional)
SUB5FILE name                (Optional)
OUTFILES FINISHED
```

Figure 4. AERMINUTE control input file structure.

4.1.1 STARTEND

The keyword STARTEND lists the start month, start year, end month and end year of data
processing. These are denoted by the variables *start_month*, *start_year*, *end_month*, and
end_year. The start day and hour are assumed to be one. The end day is the last day of the end
month and the end hour is assumed to be hour 24.

4.1.2 IFWGROUP

The keyword IFWGROUP denotes if the station is part of the Ice Free Winds (IFW) group
during the period denoted by the dates listed with STARTEND. The IFW group is composed of
NWS and FAA ASOS sites that use sonic anemometers instead of cup and vane anemometers to
measure winds. AERMINUTE treats wind speeds less than 2 knots differently based on whether
the station uses a sonic or cup and vane anemometer during the data period. A list of stations
with their IFW installation dates, as of October 27, 2009, can be found at:
http://www.weather.gov/ops2/Surface/documents/IFW_stat.pdf.   The variable, *status*, denotes if
the station is part of the IFW group. If a station is part of the IFW group during the data period
denoted by STARTEND, *status* should be set to an upper or lowercase "Y" followed by the
commission month, day, and 4-digit year. The hour of commission is assumed to be hour 1 of
the commission date. If a station is not part of the IFW group during the data period denoted by

STARTEND or is not part of the IFW group at all, *status* should be set to an uppercase or lowercase "N," and any text after the status variable is ignored. When AERMINUTE detects that the station is part of the IFW group, it checks the commission date against the end date listed in STARTEND. If the commission date is after the end date in STARTEND, AERMINUTE resets the status of the station to "no" and notifies the user. This would be the equivalent of setting IFWGROUP to "N" in the input file. If the IFW commission date is before or after the start date but is before the end date, the IFW status is left unchanged from the user input. For more information about the Ice Free Winds implementation see http://www.nws.noaa.gov/ops2/Surface/asosimplementation.htm. If the data period being processed is after 2009 and the station is not listed in the station list referenced above, it may be reasonable to assume that the station is part of the IFW group and the IFW commission date can be set to the start date set with the STARTEND keyword. Users may want to consult with NWS station responsible for the ASOS to verify if the station is part of the IFW group.

4.1.3 DATAFILE

The DATAFILE section lists the 1-minute data files to be read by AERMINUTE. The DATAFILE section begins with "DATAFILE STARTING." On lines below "DATAFILE STARTING" the user lists the 1-minute data files, one file per line. After the last file, the DATAFILE section ends with "DATAFILE FINISHED." Both "DATAFILE STARTING" and "DATAFILE FINISHED" must be present or AERMINUTE will abort and notify the user of the error if processing 1-minute data only. If including the optional 5-minute data, if both "DATAFILE STARTING" and "DATAFILE FINISHED" are not found, AERMINUTE will issue a warning and use the 5-minute data.

If multiple 1-minute data files are to be read into AERMINUTE, they do not have to be in temporal sequential order and can cover dates not included in the file processing. However, AERMINUTE will read all the data files, so if the user only wants to process a year or a few months, the user may want to list only those files, or comment out files outside the data period, to speed up processing. The files should be for one station only. If more than one station is detected by AERMINUTE based on the WBAN number, a fatal error is issued and the AERMINUTE program aborts further processing. If a change in the call sign is detected, but the WBAN number does not change, the user is warned that the station call sign has changed during processing. If the files are in the current working folder[1] or directory, just the filenames can be listed. If the files are in a different folder than the current folder, the filenames should include the full pathame of the files. If the pathname or filenames have spaces in the names, the entire text string should be enclosed in quotations. See Figure 5 for example inputs. In Figure 5a, the files are located in a folder called "example files" that is a subfolder of the current working directory. Note that the entire pathname is in quotations and that the files are not listed in sequential order; i.e. January 2003 is listed at the end. Figure 5b shows files for multiple years that are located in the current working directory.

---

[1] Current working folder refers to the folder or directory where processing is taking place. If the user is executing AERMINUTE by double clicking the AERMINUTE executable icon, the current folder is the location of the icon. If the user is executing AERMINUTE from a command line, i.e. DOS, Linux, or Unix window, the current folder or directory is the location the user is in at the time of processing.

```
"example files\64050KATL200302.dat"
"example files\64050KATL200303.dat"
"example files\64050KATL200304.dat"
"example files\64050KATL200305.dat"
"example files\64050KATL200306.dat"
"example files\64050KATL200307.dat"
"example files\64050KATL200308.dat"
"example files\64050KATL200309.dat"
"example files\64050KATL200310.dat"
"example files\64050KATL200311.dat"
"example files\64050KATL200312.dat"
"example files\64050KATL200301.dat"
```
a

```
64050KEWR200301.dat
64050KEWR200302.dat
64050KEWR200303.dat
64050KEWR200304.dat
64050KEWR200305.dat
64050KEWR200306.dat
64050KEWR200307.dat
64050KEWR200308.dat
64050KEWR200309.dat
64050KEWR200310.dat
64050KEWR200311.dat
64050KEWR200312.dat
64050KEWR200401.dat
64050KEWR200402.dat
64050KEWR200403.dat
64050KEWR200404.dat
64050KEWR200405.dat
64050KEWR200406.dat
64050KEWR200407.dat
64050KEWR200408.dat
64050KEWR200409.dat
64050KEWR200410.dat
64050KEWR200411.dat
64050KEWR200412.dat
```
b

Figure 5. Examples of inputfiles.txt for a) files enclosed in quotations, with full pathname, and out of sequential order; and b) files for multiple years in the current working directory.

4.1.3 DAT5FILE

Beginning with version 15272, AERMINUTE allows the option to process 5-minute data files (6401 format). The DAT5FILE section lists the 5-minute data files to be read by AERMINUTE. The DATAFILE section begins with "DAT5FILE STARTING." On lines below "DAT5FILE

STARTING" the user lists the 5-minute data files, one file per line. After the last file, the DAT5FILE section ends with "DAT5FILE FINISHED."   Both "DAT5FILE STARTING" and "DAT5FILE FINISHED" must be present when processing 5-minute data or AERMINUTE will abort and notify the user of the error.

As with the 1-minute data files, if multiple 5-minute data files are to be read into AERMINUTE, they do not have to be in temporal sequential order and can cover dates not included in the file processing.   However, AERMINUTE will read all the data files, so if the user only wants to process a year or a few months, the user may want to list only those files, or comment out files outside the data period, to speed up processing. The files should be for one station only. If more than one station is detected by AERMINUTE based on the WBAN number, a fatal error is issued and the AERMINUTE program aborts further processing. AERMINUTE will also abort if the WBAN number from the 5-minute files differs from those of the 1-minute files.   If a change in the call sign is detected, but the WBAN number does not change, the user is warned that the station call sign has changed during processing. File listing for the 5-minute data files is similar that described for the 1-minute data files and shown in Figure 5, i.e. use of quotations, pathnames, etc.

4.1.5 SURFDATA

The keyword SURFDATA is optional. The SURFDATA section lists data files of standard NWS observations. These are the same files that would be read by AERMET in Stage 1 processing NWS surface data. Currently, AERMINUTE is only configured to read Surface Hourly Data (ISHD) in the DS-3505 full archival format. The purpose of reading data files is to compare the non-quality controlled 1-minute winds from the 1-minute data listed in the DATAFILE section and optional 5-minute data against the quality controlled standard observations. The SURFDATA section follows the same syntax as the section.   The section starts with the keywords "SURFDATA STARTING" and ends with "SURFDATA FINISHED." The standard observation files are listed between the lines as in

Figure 4. The listing of the standard observation files also follows the convention of the 1-minute data files, i.e. files with spaces in the names must be listed in quotation marks and full or relative pathnames must be listed when the files are not in the current directory. If processing the standard observations, both "SURFDATA STARTING" and "SURFDATA FINISHED" must be present or AERMINUTE will abort and notify the user. If the SURFDATA section is missing, AERMINUTE will not abort as long as the COMPFILE keyword is not listed in the OUTFILES section (See Section 4.1.6).

4.1.6. OUTFILES

The OUTFILES section lists three files that can be output:
- *HOURFILE*: The hourly averaged winds output from AERMINUTE and formatted for input into AERMET in Stage 2. This keyword is mandatory.

- *SUMMFILE*: A comma delimited summary file that details the number of minutes used for each hour as well as minimum, maximum, and average wind speed and direction. This keyword is optional.
- *COMPFILE*: A comma delimited file that lists the winds from the 1-minute data and standard observations for all observation times listed in the standard observations file. This keyword must be present if the SURFDATA keywords are used or AERMINUTE will abort. If COMPFILE is present and the SURFDATA keywords are not present, AERMINUTE will also abort.
- *1_5_FILE*: A comma delimited file that lists the 1-minute and optional 5-minute winds for dates and times where both data are non-missing. This keyword is optional. However, if the keyword is present and the user is not inputting 5-minute data or the user is not inputting 1-minute data, AERMINUTE will abort.
- *SUB5FILE*: A comma delimited file that lists the dates and times as well as the winds from the optional 5-minute data that is substituted into the 1-minute data arrays. This keyword is optional. However, if the keyword is present and the user is not inputting 5-minute data, AERMINUTE will abort.

The syntax of the OUTFILES section is similar to DATAFILE, DAT5FILE and SURFDATA. The section starts with "OUTFILES STARTING" and ends with "OUTFILES FINISHED." Both keyword lines must be present or AERMINUTE will abort.

An example input file for Richmond, VA for 2005 is shown in Figure 6. The data period to process is January through December 2005. The IFWGROUP status is set to yes with a commission date of March 28, 2007. Because the IFW commission date is after the end date of December 31, 2005, AERMINUTE will reset the IFWGROUP status to no and notify the user. The DATAFILES section contains the 12 monthly 1-minute data files as downloaded from the NCDC website. The optional 5-minute data processing is also included. The optional comparison to the standard observations will be performed with the standard observations file listed. This should be the same file as read into AERMET for stage 1 processing of NWS data. Finally, the output files are listed and the optional summary file will be output. Since comparisons against the standard observations will be made, the optional COMPFILE must be listed as well. The optional 1-minute and 5-minute comparison file, 1_5_FILE and 5-minute substitution file, SUB5FILE are also listed.

```
STARTEND  1 2005 12 2005

IFWGROUP  y 3 28 2007

DATAFILE STARTING
64050KRIC200501.dat
64050KRIC200502.dat
64050KRIC200503.dat
64050KRIC200504.dat
64050KRIC200505.dat
64050KRIC200506.dat
64050KRIC200507.dat
64050KRIC200508.dat
64050KRIC200509.dat
64050KRIC200510.dat
64050KRIC200511.dat
64050KRIC200512.dat

DATAFILE FINISHED

DAT5FILE STARTING
64010KRIC200501.dat
64010KRIC200502.dat
64010KRIC200503.dat
64010KRIC200504.dat
64010KRIC200505.dat
64010KRIC200506.dat
64010KRIC200507.dat
64010KRIC200508.dat
64010KRIC200509.dat
64010KRIC200510.dat
64010KRIC200511.dat
64010KRIC200512.dat

DAT5FILE FINISHED

SURFDATA STARTING
724010-13740-2005.dat
SURFDATA FINISHED

OUTFILES STARTING
 HOURFILE  richmod_05.dat
 SUMMFILE  minute_summary_richmond.csv
 COMPFILE  checks_richmond.csv
 1_5_FILE  ric_15_comps.csv
 SUB5FILE ric_sub_5.csv
 OUTFILES FINISHED
```

Figure 6. Example AERMINUTE control input file.

4.2. File checking

Once AERMINUTE has read the input control file, the program reads the list of 1-minute data files and checks that each file exists and that there are no duplicate filenames. If there are non-existent files or duplicate names, AERMINUTE notifies the users of the filenames and aborts. A similar procedure is done for the 5-minute data files in the DAT5FILE section and the standard observation data files in the SURFDATA section.

4.3 Record processing

4.3.1 1-MINUTE DATA FILES

Since AERMINUTE reports running 2-minute average winds every minute, non-overlapping minutes are used in the hourly averages. That is, if winds listed at minute 2 are used, winds listed at minute 3 are not used but winds listed at minute 4 are used as they do not overlap with the minute 2 winds. Even minute winds are given first priority in calculating hourly average winds. The times listed in the data files are assumed to be the ending time, i.e. the winds listed at minute 2 are for minutes 1 and 2. Winds from minute 1 of any hour are not used at all since the 2-minute average wind spans two hours. The hourly averaged winds are assumed to be hour ending, i.e. hour 1 average winds are from hour 0, minutes 2, 4, 6, etc. Winds for hour 1, minute 0 are also part of the hour 1 averaged winds. Winds in the files are reported for hours 0 through 23. During processing, hour 0 minute 0 winds become hour 24 minute 60 winds of the previous day, since AERMET and AERMOD process hours 1 through 24.

Another issue with 1-minute ASOS wind data that influences the procedures used to process the data is that all ASOS wind speeds, including 1-minute and ASOS data and ASOS data in standard archives, are truncated, rather than rounded, to whole knots. Note that the hourly-averaged wind speeds generated by AERMINUTE are not adjusted to account for the bias introduced by truncating the ASOS wind speeds to whole knots. However, the AERMET processing, beginning with version 11059, applies the truncation adjustment for all ASOS wind speeds, including those derived from 1-minute data (EPA, 2010b).

The following steps are followed when reading a record from the 1-minute files:

- The minute in LST is read from the record. If the minute is less than zero or equal to one, the processing for that record is stopped and the next record is read.
- If the minute is valid (not less than zero or equal to one), the record format of the wind data section is checked. For details about the record format quality check see Appendix A.
- If the record passes the quality control check, the date in LST is read from the record. If the date is outside the processing range, processing stops for the record and processing for the next record begins.
- If the record's date is inside the processing date range, the 2-minute average wind speed and direction are processed as:
  - If the wind speed is less than 2 knots:

- If the station is not part of the IFW group, or the station is part of the IFW group and the date and time of the record is before the station's IFW commission date, the 2-minute wind is considered to be "calm" and the wind speed is set to half the instrument threshold, i.e., 0.51 m/s (1 knot), consistent with guidance for processing site-specific wind data. The wind speed will be used in calculating the hourly average wind speed but the direction is considered to be invalid and will not be used in calculating the hourly wind direction.
            - If the station is part of the IFW group and the record's date is on or after the station's IFW commission date, the minute is flagged as non-calm and the speeds are converted from knots to m/s, since the threshold for sonic anemometers is effectively zero. The wind speed and wind direction are used in hourly averages.
        o If the wind speed is 2 knots or greater, regardless of IFW group status and date, the 2-minute wind speed is converted from knots to m/s. The wind speed and wind direction are used in hourly averages.
        o AERMINUTE uses a unit vector approach to calculate the hourly-averaged wind direction from the 2-minute average values. The 2-minute wind directions are converted to x and y-component wind directions using Equations 1 and 2 below, which are the functions inside the summations of equations 6.2.17 and 6.2.18 of the meteorological guidance document (EPA, 2000).

$$v_x = -\sin\theta \qquad\qquad\qquad\qquad\qquad\qquad (1)$$

$$v_y = -\cos\theta \qquad\qquad\qquad\qquad\qquad\qquad (2)$$

where v_x and v_y are the x- and y-components of the 2-minute wind direction θ.

As noted in the bullets above, while reading the 1-minute data files, AERMINUTE determines if any records are within the data period set by the dates listed in STARTEND of the input file. If no records are within the data period, AERMINUTE notifies the user of the earliest and latest dates in the data files and aborts. Such a situation may occur because the user entered the wrong dates on STARTEND or the wrong data files in the DATAFILES section of the input file.

4.3.2 5-MINUTE DATA FILES

For winds, the values recorded in the 5-minute data files are the 2-minute winds at the 5 minute times, 5 minutes after the hour, 10 minutes after the hour, etc. As noted in Section 3, the 5-minute data files are more consistent in format than the 1-minute data files.

The following steps are followed when reading a record from the 5-minute files and are similar to the processing of the 1-minute files discussed in Section 4.3.1:

- The minute in LST is read from the record. If the minute is less than zero the processing for that record is stopped and the next record is read.
- If the minute is valid (not less than zero), the record format of the wind data section is checked. For details about the record format quality check see Appendix A.

- If the record passes the quality control check, the date in LST is read from the record. If the date is outside the processing range, processing stops for the record and processing for the next record begins.
- If the record's date is inside the processing date range and wind is not calm or variable, the 2-minute average wind speed and direction are processed as discussed in Section 4.3.1.
- Because the wind direction is reported to the nearest ten degrees, a randomized wind direction is calculated for the 5-minute wind direction. This step is analogous to what is done in AERMET stage 3 for wind directions at NWS sites. For example, a wind direction of 250º is reported in the 5-minute data, AERMINUTE resets the wind direction to a number between 245º and 254º, inclusive.

As noted in the bullets above, while reading the 5-minute data files, AERMINUTE determines if any records are within the data period set by the dates listed in STARTEND of the input file. If no records are within the data period, AERMINUTE notifies the user of the earliest and latest dates in the data files and notifies the user no 5-minute data substitution will occur.   Such a situation may occur because the user entered the wrong dates on STARTEND or the wrong data files in the DATAFILES section of the input file.

4.4 Data substitution and flagging 2-minute values for hourly averaging

After processing the 1-minute data files and any 5-minute data files, AERMINUTE substitutes any missing or calm 1-minute values with the values from the 5-minute data if the 5-minute value for the minute is not missing or calm (wind direction=0º and wind speed=0 m/s)[2]. After any data substitution, AERMINUTE determines if any odd minutes are to be used and which hours are to be averaged. AERMINUTE will use all non-overlapping valid minutes to calculate an hourly average. For each valid odd minute (calm or non-calm), if the even minutes just before and just after the odd minute are not valid, the odd minute is flagged as a minute that can be used. For example for hour 1, if minute 3 is valid but minutes 2 or 4 are also valid, minute 3 is not used. However, if both minutes 2 and 4 are not valid, minute 3 can be used in the hourly averaging.

After determining all minutes that can be used for averaging, AERMINUTE determines the status of the hour:

- If an hour has at least two usable non-calm observations in the first half of the hour (minutes 2 through 30) or at least one usable non-calm observation in the last half of the hour (minutes 31 through 60) and,
    - If 50% or more of the usable observations are non-calm, then an hourly wind speed and direction will be calculated for the hour or,
    - If less than 50% of the observations are non-calm, then the hour is considered calm and the wind speed and direction are set to zero.
- If the hour does not meet either of the number of observations per half hour above, average wind speed and direction will not be calculated for the hour.

---

[2] Herafter, 1-minute data refers to the original 1-minute with substituted 5-minute data.

Only non-calm observations are considered because the calm wind directions are not used. If an hour contained only calm minutes, no wind direction can be computed for the hour, and the hourly-average is coded as missing.

4.5 Quality control

Before hourly averaging of the 1-minute winds is performed, the user can direct AERMINUTE to read the standard hourly observations file that is read into AERMET. Currently this is limited to ISH (DS-3505) files. AERMINUTE reads the standard observations and compares the winds to the winds from the 1-minute data for times when there are observations in the both standard observations files and the 1-minute files. The comparison is done as a quality control step on the 1-minute data to validate against quality controlled data from the standard observations. The following checks are performed:

- For standard observations that are calm, the corresponding 1-minute data are checked for:
    - The number of missing 1-minute observations
    - The number of 1-minute observations that are less than 3 knots
    - The number of 1-minute observations that are 3 knots and greater
- For standard observations that are variable, the corresponding 1-minute data are checked for:
    - The number of missing 1-minute observations
    - The number of non-missing 1-minute observations
    - The number of observations where the absolute difference in the 1-minute wind speed and the standard observation wind speed are:
        - 0 m/s
        - 0.1 or 0.2 m/s
        - 0.3 through 0.5 m/s (inclusive)
        - 0.5 through 1.0 m/s (inclusive)
        - 1.0 through 3.0 m/s (inclusive)
        - 3.0 through 5.0 m/s (inclusive)
        - > 3.0 m/s
- For standard observations that are normal or valid, the corresponding 1-minute data are checked for:
    - The number of missing 1-minute observations
    - The number of non-missing 1-minute observations
    - The number of observations where the absolute difference in the 1-minute wind speed and the standard observation wind speed are:
        - 0 m/s
        - 0.1 or 0.2 m/s
        - 0.3 through 0.5 m/s (inclusive)
        - 0.5 through 1.0 m/s
        - 1.0 through 3.0 m/s
        - 3.0 through 5.0 m/s
        - > 5.0 m/s

- The number of observations where the absolute difference in the 1-minute wind direction (nearest 10 degrees) and standard observations are:
  - 0 degrees
  - 10 degree increments (10, 20, 30, etc.)

4.6 Averaging

Hourly averaged wind speeds are the arithmetic averages of the wind speeds for all valid minutes for the hour, including those flagged as calm, using half the threshold (Equation 3).

$$S = \frac{1}{N} \sum_{i=1}^{N} s_i \tag{3}$$

Where S is the hourly averaged wind speed, N is the number of valid observations or minutes for the hour, and s_i is the two minute wind speed for minute i.

For wind directions, the x- and y-components of non-calm observations are summed according to equations 6.2.17 and 6.2.18 of the meteorological monitoring guidance (EPA, 2000), summarized in equations 4 and 5 below with v_{xi} and v_{yi} calculated in equations 1 and 2. The hourly wind direction is calculated based on a unit-vector approach, using equation 6.2.19 of the meteorological monitoring guidance (EPA, 2000), summarized in equation 6.

$$V_X = \frac{1}{N} \sum_{i=1}^{N} v_{xi} \tag{4}$$

$$V_Y = \frac{1}{N} \sum_{i=1}^{N} v_{yi} \tag{5}$$

$$\theta = Arc \tan\left(V_X \big/ V_Y\right) + CORR \tag{6}$$

Where V_x and V_y are the hourly averaged x- and y-components of the wind respectively, θ is the hourly averaged wind direction, N is the number of observations used for the hour, and

$$CORR = \begin{cases} = 180 \text{ for } V_x > 0 \text{ and } V_y > 0 \text{ or } V_x < 0 \text{ and } V_y > 0 \\ 0 \text{ for } V_x < 0 \text{ and } V_y < 0 \\ = 360 \text{ for } V_x \geq 0 \text{ and } V_y < 0 \end{cases}$$

5. Outputs

Up to eight output files are generated by AERMINUTE, depending on the user options:

- Hourly averaged winds file (HOURFILE), formatted for input to AERMET Stage 2
- Good_records.dat

- Bad_records.dat
- Check_records.dat
- Optional summary file (SUMMFILE)
- Optional standard observations vs. 1-minute data file (COMPFILE)
- Optional 1-minute and 5-minute comparison file (1_5_FILE)
- Optional file listing of minutes substituted with 5-minute data (SUB5FILE)
- AERMINUTE.log

5.1 Hourly winds (HOURFILE)

The hourly average winds file is the file that is input to AERMET stage 2 processing. The filename is set by the user using the HOURFILE keyword in the control input file. The file format of the hourly averaged file is shown in Figure 7. The first line of the file contains information about the AERMINUTE program and the station: AERMINUTE version number, station WBAN, 4-character station call sign, IFW status, IFW date, and beginning with AERMINUTE version 15272, whether 5-minute data is used ("Y" for yes, "N" for no). If the station is part of the IFW group for the data period, the IFW status is "Y." Otherwise it is "N." The IFW flag is considered for the data period only. If the station becomes part of the IFW group after the data period, the flag will be set to "N." If the station is part of the IFW group for the data period, the IFW installation date is listed as a character string composed of 4-digit year, 2-digit month, and 2-digit day. If the station is not part of the IFW group for the data period, the IFW date is not listed. For the example shown Figure 7, Richmond International Airport (KRIC) does not become part of the IFW group until March 28, 2007, so the IFW status is no and the date is not included.

Beginning with line two, the hourly averaged winds are listed. The order of variables is listed in Figure 7. AERMINUTE writes the output in a fixed format, but AERMET reads the data in free format, i.e. the data fields are separated by spaces. AERMINUTE writes to a fixed format for visual purposes only. For hours that are missing or not considered valid due to an insufficient number of non-calm observations, the wind speed and direction are both set to 999.0. Calm hours are denoted by a wind speed of 0.0 and wind direction of 0.0.

```
AERMINUTE  Version 15272   WBAN: 13740    Call sign: KRIC    IFW: N 5-MIN USED: Y
 5  1  1  1    2.50 201.0
 5  1  1  2    2.29 208.0
 5  1  1  3    2.35 197.0
 5  1  1  4    1.05 199.0
 5  1  1  5    0.97 188.0
 5  1  1  6    2.21 193.0
 5  1  1  7    2.28 193.0
 5  1  1  8    1.78 183.0
 5  1  1  9    0.00   0.0
```

Variables
2-digit year
2-digit month
2-digit day
2-digit hour (1-24)
Wind speed (m/s)
Wind direction (degrees)

Figure 7. Example hourly averaged winds and order of variables.

5.2 Record check files

AERMINUTE generates three files that contain the full 1-minute data records as read from the 1-minute data files, depending on whether AERMINUTE determines that the record contains "good" data that can be used to calculate the hourly averages, the record do not meet strict quality control checks on the format but may contain useable data, or the record is unusable due to serious formatting problems. Each of these categories of data records are written to separate files in order to fully document the data that were used or rejected by AERMINUTE.

The file 'good_records.dat' contains the records from the 1-minute files that meet the strict quality control checks in AERMINUTE and the winds from these files are considered valid. A detailed description of the quality control check is in Appendix A. These records include those observations for odd minutes that may or may not be used in hourly averages. The user should be able to rename good_records.dat (to avoid overwriting the data during processing), replace the files listed in inputfiles.txt with the renamed file and rerun AERMINUTE and get the exact same answers as using the full list of inputs. An example of good_records.dat is shown in Appendix A.

The second file is called 'check_records.dat'. This is a file containing records that did not meet the strict quality control of AERMINUTE and are not used in calculating hourly averages, but the wind observations are close to the locations, i.e. column locations, set by strict quality control. These records also contain the flags detailing the quality control failures. See Appendix A for an example of check_records.dat. Often, manual editing by the user could allow these records to be used by AERMINUTE. When viewing the data, the user should check observations in good_records.dat from the same hour to determine if data is reasonable when compared to other observations for the hour. If there is any doubt about the record, the 'check_records.dat' data should not be used in the hourly averages.

A third file output by AERMINUTE is called 'bad_records.dat'. This file contains records from the 1-minute files that did not meet the strict quality controls in AERMINUTE, and are unlikely

to contain usable data. This file also includes flags indicating what quality control checks failed. These records do not meet the criteria outlined for acceptance into good_records.dat and are not used.   See Appendix A for details about the flags. This file should be reviewed by the user since the quality and formatting of the 1-minute files varies from station to station and by year.

If the user determines that additional valid data can be obtained by appropriately editing the 'check_records.dat' data file, the user can rename the 'good_records.dat' and 'check_records.dat' files, replace the files listed in the control input file with these renamed files and rerun AERMINUTE to get new hourly averages.

Similar files to the good, bad, and check record files for the 1-minute files are generated for the 5-minute data files, when processed. These files are called 'good_records_5.dat' and bad_records_5.dat.' These files are analogous to 'good_records.dat' and 'bad_records.dat.' A third file called 'calm_variable_5.dat' is generated for the 5-minute data and it contains the records that are calm or variable in the 5-minute data. These are records where the winds are reported as '00000KT' for calms and contain the string 'VRB' in the wind direction field for variable winds, i.e. 'VRB03KT'. Records in 'bad_records_5.dat' and 'calm_variable_5.dat' are not used in 5-minute data processing.

5.3 Summary file (SUMMFILE)

AERMINUTE can also output a comma delimited summary file that is named via the optional SUMMFILE keyword in the AERMINUTE input file. The SUMMFILE lists each hour in the data period, including those not in the 1-minute files, with counts of minutes for the hour and can be used as a quality assurance check against the hourly averaged winds file. Also included for each hour are the minimum and maximum 2-minute wind speed and direction used in the hourly calculations, as well as the hourly averaged wind speed and direction that are listed in the HOURFILE. The minimum wind speed and direction are unpaired in time, i.e. they may not represent the same time. The same is true for the maximum wind speed and direction. An example of the file is shown in Figure 8, along with the format. In this example, 5-minute data was not read by AERMINUTE. Figure 9 shows an example summary file with 5-minute information. When 5-minute data is read by AERMINUTE, the summary file lists the number 5-minute values substituted into the 1-minute data as well as the source (1 or 5 minute data) of the minimum and maximum wind speeds and minimum and maximum wind directions. If there were observations for an hour, the keep flag for the hour is "V", "C", or "NV." Hours with a keep flag of "V" have hourly averaged winds in the hourly average winds file. Hours with a keep flag of "C" are calm hours. Hours with a keep flag of "NV" had observations for the hour but did not meet the completeness criteria for the hour. Hours that were not in the files or had no minutes in the file that met the quality control criteria are denoted by "M" for the keep flag. After the keep flag, the IFW status of the hour is shown. A value of 0 means that the station was not part of the IFW group for that hour. Missing hours will always have a value of 0 for the IFW group. A value of 1 denotes the station was part of the IFW group for the hour. For the minute counts, the number of total minutes read for the hour, total calms, even minutes, even calms, odd minutes, odd calms, odd minutes used in hourly averages, and odd calms used in hourly averages are listed. When processing 5-minute data files, these counts include any substituted 5-minute data. The maximum number of total minutes or total calms for an hour is 59. The maximum

number of even minutes or even calms for an hour is 30. The maximum number of odd minutes or odd calms is 29 (minute 1 is excluded). The maximum number of odd minutes used or odd calms used is 29. If the number of odd minutes used or odd calms used is 29, then the number of even minutes should be zero, since overlapping observations are not used. When reviewing the minute counts and looking at the raw 2-minute winds, the user should remember that the counts for an hour are for minutes whose actual reporting hour is the hour before; i.e. counts for 0100 are for minutes whose reported hour in the 1-minute files is hour 00.

Date,hr,flag,IFW flag,total minutes,total calms,total even,even calms,total odd,total odd calm,odd used,odd calms used,min speed,avg speed,max speed,min dir,avg dir,max dir
20050101,01,V , 0,59, 0,30, 0,29, 0, 0, 0, 1.53, 2.50, 3.57,182,201,217
20050101,02,V , 0,59, 0,30, 0,29, 0, 0, 0, 1.53, 2.29, 2.55,191,208,225
20050101,03,V , 0,59, 0,30, 0,29, 0, 0, 0, 1.53, 2.35, 3.06,184,197,223
20050101,04,V , 0,59,18,30, 9,29, 9, 0, 0, 0.51, 1.05, 2.04,176,199,279
20050101,05,V , 0,59,28,30,14,29,14, 0, 0, 0.51, 0.97, 1.53,157,188,209
20050101,06,V , 0,59, 0,30, 0,29, 0, 0, 0, 1.53, 2.21, 3.06,186,193,199

Variables	
Date	Date of observation (YYYYMMDD)
Hr	Hour of observation (01-24)
Flag	Flag denoting if hour is valid (V), calm (C), non-valid (NV), or missing (M)
IFW flag	Integer code corresponding to IFW status (0=not IFW during data period, 1=part of IFW group during data period)
Total minutes	Total number of minutes read from 1-minute files for hour
Total calms	Total number of calm minutes for hour
Total even	Total even minutes read from files for hour
Even calms	Total number of even minutes with calm winds for hour
Total odd	Total odd minutes read from files for hour
Total odd calm	Total number of odd minutes with calm winds for hour
Odd used	Total odd minutes used in hourly average winds for hour
Odd calms used	Total number of odd minutes with calm winds used in hour average winds for hour
Min speed	Minimum 2-minute wind speed (m/s) for the hour
Avg speed	Hourly averaged wind speed (m/s)
Max speed	Maximum 2-minute wind speed (m/s) for the hour
Min dir	Minimum 2-minute wind direction (m/s) for the hour
Avg dir	Hourly averaged wind direction
Max dir	Maximum 2-minute wind direction (m/s) for the hour

Figure 8. Format of SUMMFILE when 5-minute data is not read by AERMINUTE.

Date,hr,flag,IFW flag,total minutes,total 5-min subs,total calms,total even,total even 5-min subs,even calms,total odd,total odd 5-min subs,total odd calm,odd used,odd calms used,min speed,min speed source,avg speed,max speed,max speed source,min dir,min dir source,avg dir,max dir,max dir source		
20050101,01,V , 0,59, 0, 0,30, 0, 0,29, 0, 0, 0, 0, 1.53, 1, 2.50, 3.57, 1,182, 1,201,217, 1		
20050101,02,V , 0,59, 0, 0,30, 0, 0,29, 0, 0, 0, 0, 1.53, 1, 2.29, 2.55, 1,191, 1,208,225, 1		
20050101,03,V , 0,59, 0, 0,30, 0, 0,29, 0, 0, 0, 0, 1.53, 1, 2.35, 3.06, 1,184, 1,197,223, 1		
20050101,04,V , 0,59, 0,18,30, 0, 9,29, 0, 9, 0, 0, 0.51, 1, 1.05, 2.04, 1,176, 1,199,279, 1		
20050101,05,V , 0,59, 0,28,30, 0,14,29, 0,14, 0, 0, 0.51, 1, 0.97, 1.53, 1,157, 1,188,209, 1		
20050101,06,V , 0,59, 0, 0,30, 0, 0,29, 0, 0, 0, 0, 1.53, 1, 2.21, 3.06, 1,186, 1,193,199, 1		
Variables		
Date	Date of observation (YYYYMMDD)	
Hr	Hour of observation (01-24)	
Flag	Flag denoting if hour is valid (V), calm (C), non-valid (NV), or missing (M)	
IFW flag	Integer code corresponding to IFW status (0=not IFW during data period, 1=part of IFW group during data period)	
Total minutes	Total number of minutes read from 1-minute files for hour	
Total 5-min subs	Total number of minutes 5-minute data was substituted into 1-minute data	
Total calms	Total number of calm minutes for hour	
Total even	Total even minutes read from files for hour	
Total even 5-min subs	Total number of even minutes substituted with 5-minute data	
Even calms	Total number of even minutes with calm winds for hour	
Total odd	Total odd minutes read from files for hour	
Total odd 5-min subs	Total number of odd minutes substituted with 5-minute data	
Total odd calm	Total number of odd minutes with calm winds for hour	
Odd used	Total odd minutes used in hourly average winds for hour	
Odd calms used	Total number of odd minutes with calm winds used in hour average winds for hour	
Min speed	Minimum 2-minute wind speed (m/s) for the hour	
Min speed source	Source of minimum wind speed (1=1-minute data, 5=5-minute data)	
Avg speed	Hourly averaged wind speed (m/s)	
Max speed	Maximum 2-minute wind speed (m/s) for the hour	
Max speed source	Source of maximum wind speed (1=1-minute data, 5=5-minute data)	
Min dir	Minimum 2-minute wind direction (m/s) for the hour	
Min dir source	Source of minimum wind direction (1=1-minute data, 5=5-minute data)	
Avg dir	Hourly averaged wind direction	
Max dir	Maximum 2-minute wind direction (m/s) for the hour	
Max dir source	Source of maximum wind direction (1=1-minute data, 5=5-minute data)	

Figure 9. Format of SUMMFILE when 5-minute data is read by AERMINUTE.

5.4 Comparison file (COMPFILE)

AERMINUTE can output the optional COMPFILE that compares the standard observations against the 1-minute observations. The file is comma delimited and the format of the file is shown in Figure 10 using Richmond, VA (RIC) as an example. The file can be imported into a spreadsheet program where the user can look at specific observations to determine if the 1-minute data and the standard observations are in reasonable agreement. For minutes where either the standard observation is missing or the 1-minute data is missing, speeds and directions are listed as 999 and differences as -999.

date(yyyymmdd),hour,minute,calm flag,1-min dir,1-min dir10,1-min speed,1-min speed_1,obs. dir,obs. speed,dirdiff,speeddiff,wind flag,qc flag
20050101, 1, 0,0, 209.0, 210.0, 1.5, 1.5, 210.0, 2.1, 0.0, 0.6,N,5
20050101, 2, 0,0, 198.0, 200.0, 2.0, 2.0, 999.0, 999.9, -999.0, -999.0,9,9
20050101, 3, 0,0, 223.0, 220.0, 1.5, 1.5, 999.0, 999.9, -999.0, -999.0,9,9
20050101, 4, 0,0, 184.0, 180.0, 1.0, 1.0, 999.0, 999.9, -999.0, -999.0,9,9
20050101, 5, 0,0, 185.0, 190.0, 1.5, 1.5, 999.0, 999.9, -999.0, -999.0,9,9
20050101, 6, 0,0, 193.0, 190.0, 2.5, 2.6, 999.0, 999.9, -999.0, -999.0,9,9

Variables	
Date(yyyymmdd)	Date of observation with 4-digit year, month, and day
Hour	Hour of observation (1-24)
Minute	Minute of observation
Calm flag	Integer flag denoting if 1-minute observation is considered calm (0=non-calm,1=calm)
1-min dir	1-minute direction from 1-minute data files
1-min dir10	1-minute direction from 1-minute data files rounded to nearest ten degrees
1-min speed	1-minute wind speed (m/s)
1-min speed_1	1-minute wind speed rounded to nearest tenth of a m/s
Obs. dir	Wind direction from standard observations
Obs. speed	Wind speed (m/s) from standard observation
dirdiff	Difference between 1-minute wind direction and standard observation direction, i.e. 1-min dir10 – obs. dir
speeddiff	Difference between 1-minute wind speed and standard observation speed, i.e. 1-min speed_1– obs. speed
Wind flag	Wind observation type code from standard observation C=calm N=normal R=60 minute average speed Q=squall V=variable 9=missing
QC flag	Wind observation speed quality code from standard observation 0 = Passed gross limits check 1 = Passed all quality control checks 2 = Suspect 3 = Erroneous 4 = Passed gross limits check , from DSI-3280 or NCDC ASOS/AWOS 5 = Passed all quality control checks, from DSI-3280 or NCDC ASOS/AWOS 6 = Suspect, from DSI-3280 or NCDC ASOS/AWOS 7 = Erroneous, from DSI-3280 or NCDC ASOS/AWOS 9 = Passed gross limits check if element is present

Figure 10. Format of COMPFILE.

5.5 1-minute and 5-minute comparison file (1_5_FILE)

AERMINUTE can output the optional 1-minute vs. 5-minute comparison file, 1_5_FILE when 5-minute data is processed by AERMINUTE. This file can be used to determine the agreement between the 1-minute and 5-minute data after processing discussed in Section 4.3. A sample file with format is shown in Figure 11. Note, that in some cases the winds between the 1- and 5-minute data may not be equal. This may be due to multiple observations in one or both datasets for a particular time. In such occurrences, AERMINUTE keeps the latest of the observations. For observations where the 5-minute indicates a calm, it must be noted that the calms and variable processing of the METAR code is used on the 5-minute data.

date(yyyymmdd),hour,minute,1-min dir,1-min speed,5-min 10 deg dir,5-min dir,5-min speed	
20050101, 1, 5,181, 3.06,180,183, 3.06	
20050101, 1,10,197, 3.06,200,196, 3.06	
20050101, 1,15,197, 2.55,200,196, 2.55	
20050101, 1,20,194, 3.06,190,194, 3.06	
20050101, 1,25,195, 3.06,200,202, 3.06	
20050101, 4,10,244, 0.51, 0, 0, 0.00	
20050101,13,55,270, 1.53,VRB,VRB, 1.53	
Variable	
Date(yyyymmdd)	Date of observation with 4-digit year, month, and day
Hour	Hour of observation (1-24)
Minute	Minute of observation
1-min dir	1-minute dataset wind direction
1-min speed	1-minute dataset wind speed (m/s)
5-min 10 deg.	5-minute dataset wind direction to nearest 10º. 'VRB' indicates variable wind direction
5-min dir	5-minute dataset randomized wind direction. 'VRB' indicates variable wind direction
5-min speed	5-minute dataset wind speed (m/s)

Figure 11. Format of 1_5_FILE.

5.6. List of substituted minutes (SUB5FILE)

Another optional output file from AERMINUTE when processing 5-minute data is a comma delimited file that lists the dates and times where 5-minute data is substituted into the 1-minute data, SUB5FILE. For such times, the 1-minute data is missing and 5-minute data is not missing and not calm. Figure 12 shows a sample file and format of the file.

date(yyyymmdd),hour,minute,5-min dir,5-min speed	
20050110,18,50, 26, 2.04	
20050110,18,55, 50, 4.59	
20050110,18,60, 69, 3.57	
20050110,19, 5, 60, 3.06	
20050110,19,10, 63, 3.57	
20050110,19,15, 69, 3.57	
20050110,19,20, 66, 3.57	
Variable	
Date(yyyymmdd)	Date of observation with 4-digit year, month, and day
Hour	Hour of observation (1-24)
Minute	Minute of observation
5-min dir	5-minute dataset randomized wind direction.
5-min speed	5-minute dataset wind speed (m/s)

Figure 12. Format of SUB5FILE.

5.7. Log file

During processing AERMINUTE writes information to the screen and a log file called, aerminute.log. In Figure 13, a summary of the user inputs is listed. First, the AERMINUTE version number and program start date and time are listed. Listed below those lines are a summary of the processing dates and IFW status as well notifying the user that 5-minute data will be read. In this example, the data period is from January 1 through December 31 2005. The user entered that the station is part of the IFW group with a start date of March 28, 2007. AERMINUTE notifies the user that this date is outside the range of processing dates. Therefore, the IFW status of the station will be set to no.

```
AERMINUTE VERSION 15272
 Program start date & time: September 30, 2015  11:49:18 AM


 ############################## INPUTS ##############################

 Control input file: aerminute.inp
 Summary of dates
 Start date:  1  1 2005
 End Date: 12 31 2005

 Station is part of IFW group
 With start date of  3 28 2007
 But is outside of the range of processed dates


 5-minute files will be read


 ####################################################################
```

Figure 13. Input summary section of aerminute.log.

After the user input summary, AERMINUTE checks for existence of the files listed in the DATAFILES section and if there are any duplicate filenames. The same is done for the DAT5FILES section, if listed. Also, if any files are listed in the SURFDATA section, the existences of the listed files are checked as well to see if there are any duplicate filenames. In

Figure 14, AERMINUTE finds 12 1-minute data files without any duplicate names as well as 12 5-minute data files without any duplicate names. AERMINUTE finds one standard observation file to read and reads the file.

```
######################### 1 -MINUTE DATA FILES CHECK #####################

 Checking for duplicate filenames

 No duplicate filenames found

 All files found...
 Number of files to process:  12

 #######################################################################

 ######################### 5 -MINUTE DATA FILES CHECK #####################

 Checking for duplicate filenames

 No duplicate filenames found

 All files found...
 Number of files to process:  12

 #######################################################################

 ######################### SURFACE FILES CHECK #########################

 Obtaining surface data filenames

 Checking for duplicate surface filenames

 No duplicate filenames found

 Reading surface files
 Reading surface file 724010-13740-2005

 #######################################################################
```

Figure 14. Data file check section of AERMINUTE.LOG

After reading the standard observation files, AERMINUTE reads the 1-minute data files and lists the files as they are processed. After processing the files, AERMINUTE lists the number of processed and non-processed records. Under the processed record counts, the number of records outside the data period set by the start and end dates are listed and the number of records within the data period are also listed. Under the non-processed records count, subtotals are provided for records that are minute 1, bad, need checking, or had a bad record for the time. The last subtotal should be zero, unless there was a severe formatting problem with a file. After the subtotal of records, AERMINUTE lists the number observations that failed the various quality assurance checks. These counts are not mutually exclusive; some records may fail multiple checks. Figure 15 lists the record totals and quality assurance checks totals. Note that for the non-processed

record counts and the number of observations that failed various quality control checks, the counts include observations outside and within the data period set by the start and end dates.

```
###################### 1-MIN FILE PROCESSING ######################

 Reading 64050KRIC200501.dat

 Reading 64050KRIC200502.dat

 Reading 64050KRIC200503.dat

 Reading 64050KRIC200504.dat

 Reading 64050KRIC200505.dat

 Reading 64050KRIC200506.dat

 Reading 64050KRIC200507.dat

 Reading 64050KRIC200508.dat

 Reading 64050KRIC200509.dat

 Reading 64050KRIC200510.dat

 Reading 64050KRIC200511.dat

 Reading 64050KRIC200512.dat

 All files read...

 RECORD FORMAT QA

 Total number of records read from files:          458902
 Number of processed records:                      450677
 Number of records outside data period:                 1
 Number of records inside data period:             450676
 Number of non-processed records:                    8225
 Number of records for minute 1:                     7646
 Number of bad records:                               437
 Number of check records:                             142
 Number of bad minute records:                          0
 NOTE: Number of non-processed records includes records outside data period

 QA FLAG SUMMARY COUNT
 FLAG                  DESCRIPTION                                      RECORDS
  1    Non-numeric characters in columns 68 through 90                      246
  2    Text string with leading zero in columns 66 through 90                93
  3    4-character numeric string found in columns 30 through 113           164
  4    Column 30 is non-blank                                                67
  5    No number in columns 70-74 for 2-minute wind direction              283
  6    No number in columns 76-79 for 2-minute wind speed                  296
  7    No number in columns 82-84 for 5-second gust wind direction         284
  8    No number in columns 87-89 for 5-second gust wind speed             291
  9    Number in column 90                                                  196
 10    Wind speeds and directions outside allowable ranges                    4
 11    Other flags switched on, but winds may be okay                       142
 11    Other flags switched on, but record is bad                          437

 ####################################################################
```
Figure 15. 1-minute file processing section of aerminute.log.

31

If 5-minute data is to be read by AERMINUTE, AERMINUTE reads the files and notifies the users that the files are being processed (Figure 16).

```
######################### 5-MIN FILE PROCESSING #######################

Reading 64010KRIC200501.dat

Reading 64010KRIC200502.dat

Reading 64010KRIC200503.dat

Reading 64010KRIC200504.dat

Reading 64010KRIC200505.dat

Reading 64010KRIC200506.dat

Reading 64010KRIC200507.dat

Reading 64010KRIC200508.dat

Reading 64010KRIC200509.dat

Reading 64010KRIC200510.dat

Reading 64010KRIC200511.dat

Reading 64010KRIC200512.dat

All files read...
```

Figure 16. 5-minute file processing section of aerminute.log.

After reading the 1-minute and any 5-minute data files, AERMINUTE substitutes the 5-minute data into the 1-minute data, if 5-minute data is present. AERMINUTE then compares the updated 1-minute data against the standard observations as outlined in Section 4.5, if the optional COMPFILE keyword is specified. AERMINUTE lists the summaries for standard calm winds, standard missing winds, standard variable winds, and standard valid winds in AERMINUTE.LOG (Figure 17).

```
########################### DATA QC SUMMARY ###########################

STANDARD CALMS
   Number of standard observation calms:     1038
   Number of missing 1-minute winds:          170
   Number of 1-minute winds < 3 knots:        842
   Number of 1-minute winds >= 3 knots:        28

 STANDARD MISSING WINDS
   Number of standard observation missing winds:   3697
   Number of missing 1-minute winds:                274
   Number of non-missing 1-minute winds:           3423

STANDARD VARIABLE WINDS
   Number of standard observation variable winds:    132
   Number of missing 1-minute winds:                  17
   Number of non-missing 1-minute winds:             115

 VARIABLE WINDS:  SPEED DIFFERENCES (M/S)
 Speed difference     Number of minutes
        0                   65
    <= 0.2                  29
 0.3 - 0.5                   7
 0.5 - 1.0                   2
 1.0 - 3.0                  12
 3.0 - 5.0                   0
     > 5.0                   0

 STANDARD VALID WINDS   Number of standard observation valid winds:   4488
   Number of missing 1-minute winds:               677
   Number of non-missing 1-minute winds:          3811

 VALID WINDS:  SPEED DIFFERENCES (M/S)
 Speed difference     Number of minutes
        0                 2223
    <= 0.2                1099
 0.3 - 0.5                 198
 0.5 - 1.0                 134
 1.0 - 3.0                 131
 3.0 - 5.0                  22
     > 5.0                   4

 VALID WINDS:  DIRECTION DIFFERENCES (DEG)
  Direction difference   Number of minutes
     0                     3362
 <=  10                     291
 <=  20                      85
 <=  30                      37
 <=  40                      17
 <=  50                       6
 <=  60                       4
 <=  70                       2
 <=  80                       1
 <=  90                       2
 <= 100                       0
 <= 110                       1
 <= 120                       1
 <= 130                       0
 <= 140                       1
 <= 150                       1
 <= 160                       0
 <= 170                       0
 <= 180                       0
  > 180                       0

 #######################################################################
```

Figure 17.   Quality control summaries listed in AERMINUTE.LOG.

After file processing and hourly averaging, AERMINUTE writes a summary of the winds to the screen and log (Figure 18). AERMINUTE lists the minimum and maximum 2-minute wind speeds processed along with their directions and date/times. Beginning with version 15272, the source of the minimum and maximum winds, 1-minute or 5-minute is also listed. The dates and times listed are the actual reported time for the observations.   AERMINUTE also lists the minimum and maximum hourly averaged winds with their directions and date/times. After the summaries, AERMINUTE lists the number of hours in the data period. This is the number of calendar hours, not just hours processed by AERMINUTE.   In this example, since an entire year is processed, there are 8,760 hours in the data period. AERMINUTE then lists the number of processed hours, valid hours, invalid hours, and calm hours along with percentages of the data period.   Valid hours are those hours that met the observation criteria in Section 4.3 and 50% or more of the observations were non-calm. Calm hours are hours that met the observation criteria in Section 4.3 but had more than 50% calm observations. Invalid hours are those hours that did not meet the observation criteria in Section 4.3. AERMINUTE also lists the number of valid, invalid, calm, missing, and total hours by month, where total hours it the number of hours in the month, including hours not processed. If 5-minute data is processed, the number of substituted minutes per month is also listed. Finally, AERMINUTE lists the stop time of the program and if the program terminated normally.

```
############################ SUMMARY ############################


Minimum 2-minute wind speed (knots), direction and original date (YYYYMMDDHHmm)
   0.00 253 200501010312   *1-minute data
 Maximum 2-minute wind speed (knots), direction and original date (YYYYMMDDHHmm)
  47.00  39 200510050010   *1-minute data



 Minimum hourly wind speed (m/s), direction and date (YYYYMMDDHH)
   0.77 170.0 2005012020
 Maximum hourly wind speed (m/s), direction and date (YYYYMMDDHH)
  12.04 353.0 2005030810



 Number of total hours in data period:    8760
 Number of processed hours:              7959 ( 90.86%)
 Number of valid hours:                  7034 ( 80.30%)
 Number of processed non-valid hours:     393 (  4.49%)
 Number of calm hours:                    532 (  6.07%)


                    TOTAL   VALID  INVALID   CALM   MISSING   5-MIN
 YEAR     MONTH     HOURS   HOURS   HOURS    HOURS   HOURS   MINUTES
 -------------------------------------------------------------------
 2005    January    744     678       4      24       38       10
 2005    February   672     611      29      29        3       92
 2005    March      744     624      19      27       74       19
 2005    April      720     509      21      31      159        0
 2005    May        744     610      19      50       65        4
 2005    June       720     588      29      54       49        1
 2005    July       744     569      37      82       56       36
 2005    August     744     478      73      98       95     1035
 2005    September  720     426     132      42      120      741
 2005    October    744     644       7      32       61       67
 2005    November   720     665       7      22       26        6
 2005    December   744     632      16      41       55        1


 ###################################################################

 Normal termination

 Program end date & time: September 30, 2015  11:49:51 AM
```
Figure 18. Summary section of aerminute.log

6. References

EPA, 2000: Meteorological Monitoring Guidance for Regulatory Modeling Applications. EPA-454/R-99-005. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

EPA, 2010a: Addendum - User's Guide for the AMS/EPA Regulatory Model – AERMOD. EPA-454/B-03-001. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

EPA, 2010b: Addendum - User's Guide for the AERMOD Meteorological Preprocessor (AERMET). EPA-454/B-03-002. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

Appendix A: Record Quality Control Check Methodology

This appendix details the quality control checks made on 1-minute data records and 5-minute data records. Below are the quality control flag descriptions as well as example good_record.dat, bad_record.dat, and check_record.dat files. The following quality control checks are made on each record of the 1-minute files. The checks are made in the order shown in Table A-1. Flag values of 0 are pass, values of 1 are fail.

Table A-1. Quality control checks on 1-minute winds read by AERMINUTE.

Flag	Check	Flag value	
		0	**1**
1	Check columns 68 through 90 for non-numeric characters. Columns 67 through 90 should only contain numbers or spaces.	No non-numeric characters in the column range	At least one non-numeric character in the column range.
2	Check columns 66 through 90 for character strings that have a leading space followed by a zero and then a non-zero number (" 01", " 02", etc.)	No text strings of leading zero in column range.	Text string with leading zero present in column range.
3	Check columns 30 through 113 for a 4-character string, consisting of numbers representing a possible time, i.e. 11:11 AM would be ' 1111' or 10:59 PM would be ' 2259'. These strings should not be in the record after column 29.	No strings found	A time string found in columns 38 through 90
4	Check column 30 for non-blank character. Column 30 should be blank.	Column 30 is blank	Column 30 is not blank
5	Check column 67 for any non-blank character. There should not be non-blank character in column 67.	Column 67 is blank	Column 67 is non-blank
5	Check columns 70-74 for the 2-minute average wind direction.	Any column contains a numeric character and no non-numeric characters	Columns 70-74 are blank or non-numeric
6	Check columns 76-797 for the 2-minute average wind speed.	Any column contains a numeric character and no non-numeric characters	Columns 76-79 are blank or non-numeric
7	Check columns 82-84 for the five second gust wind direction.	Any column contains a numeric character and no non-numeric characters	Columns 82 and 84 are blank or non-numeric
8	Check columns 87-89 for the 2-minute average wind speed.	Any column contains a numeric character and no non-numeric characters	Columns 87-89 are blank or non-numeric
9	Check column 90 for blank character	Column 90 is blank	Column 90 is non-blank
10	If flags one through nine are all zero, check for the number of fields. If the number of fields is 4, read the 2-minute average wind direction, 2-minute average wind speed, five second gust direction, and five second gust speed from columns 68 through 90. If directions or speeds do not meet range check set flag 10 to 1. Also set the 11th flag equal to 9, regardless of direction and speed check just noted. If the number of fields is not 4 set the 10th flag to 1 and the 11th flag to the number of fields.	If flags 1 through 9 are zero and wind data meets range criteria **OR** One of the flags 1 through 9 is non-zero. Check for flag 10 is not performed so flag is left at zero.	Wind data does not meet range criteria.

If flags 1 through 9 are zero and flag 10 is zero, flag 11 is set to 9. AERMINUTE will check for the number of fields and if the number of fields is not equal to 4 then flag 10 is set to 1 and flag 12 is set equal to the number of fields. If at least one of the flags is equal to one and flags 2 and 3 flags are zero, the record may be usable but does not fit the strict quality control criteria. AERMINUTE reads columns 68 through 90 and checks for four or five numeric fields. If four or five numeric fields are found, AERMINUTE performs the same checks as done for flag 10; positive wind directions less than or equal to 360 degrees and positive wind speeds less than 50 knots. If these conditions are not met, set flag 11 equal to eight. Otherwise if at least one of the conditions is met, set flag 11 equal to the number of numeric fields read from the line. If four or five fields are not found, set the thirteenth flag equal to the number of fields read from the line.

Once all 11 flags have been set, get the maximum value among flags 1 through 10. If the maximum value is zero, the record is considered good and will be further processed. Also write the record to good_records.dat.   If the maximum value for the first ten flags is not zero and the eleventh flag is equal to four or five, write the line to check_records.dat. If the maximum value among the first ten flags is not zero and the eleventh flag is not equal to four or five, write the record to bad_records.dat. Do not use the record if it is written to bad_records.dat or check_records.dat

In Figure A-1, are example records from good_records.dat which contains records that meet the strict quality control checks above. Records in this file have zeros for the first ten flags and a value of nine for the eleventh flag. The flags are not displayed for these records. The text string "123456 1234 123 1234" is used as reference to denote where the wind variables should generally be:

  123456   2-minute average wind direction
  1234   2-minute average wind speed (whole knots)
  123   5-second maximum wind gust's direction
  1234   5-second maximum wind gust's speed (whole knots)

In Figure A-1, the actual column numbers in the data file for each of the above text strings are listed above each string, i.e., "123456" corresponds to columns 68 through 73. Also shown in Figure A-1, is the location of column 39. The above checks are met (in order as listed above):

- No non-numeric characters in columns 67 through90
- No leading zero numbers in columns 66 through 90
- No possible time strings outside of the station/date information block
- Column 30 is blank
- A number is present in at least one column of columns 70-74
- A number is present in at least one column of columns 76-78
- A number is present in at least one column of columns 82-84
- A number is present in at least one column of columns 87-89
- Column 90 is blank
- All above conditions are met, read the wind data and winds meet direction and speed criteria

30			68-73	75-78	81-83	86-89
			123456	1234	123	1234
13740KRIC RIC2005010100000500	0.150	N	180	4	185	5	34 60+
13740KRIC RIC2005010100020502	0.152	N	188	5	189	5	34 60+
13740KRIC RIC2005010100030503	0.153	N	189	5	187	5	34 60+
13740KRIC RIC2005010100040504	0.152	N	186	5	180	6	34 60+
13740KRIC RIC2005010100050505	0.153	N	181	6	179	7	34 60+
13740KRIC RIC2005010100060506	0.154	N	182	7	184	7	34 60+

Figure A-1. Example good_records.dat file.

In Figure A-2, are example records from check_records.dat. In check_records.dat, the values for the eleven flags are listed at the end of the record. The text strings are as described for Figure A-1. For a record to be written to check_records.dat, flags 1, 2 and 3 must be zero, no non-numeric characters in columns 68 through 90 (flag 1), no leading zero numbers (flag 2), and no 4-digit time strings (flag 3). Also, four numeric fields should be present in columns 67 through 90 and at least one of the wind data fields meet the wind direction and speed range criteria. Table A-2 describes the situations found for each data record and possible solutions.

30		68-73	75-78	81-83	86-89	
		123456	1234	123	1234	
13740KRIC RIC2005020916142114	0.069 D	174	3	168	2115	0.069	00100001104
13740KRIC RIC2005020919160016	0.111 N	197	5	196	5 34	0018	00100000004
13740KRIC RIC2005020922190319	0.132 N	200	9	202	11 34	0321	00100000004
13740KRIC RIC2005021003200820	0.265 N	308	10	310	11 34	0822	00100000004
13740KRIC RIC2005021015392039	0.050 D	302	18	295	22 34	2040	00100000004
13740KRIC RIC2005021102450745	0.050 N	309	9	311	13 34	0747	00100000004
13740KRIC RIC2005030713051805	40000.00 M	205	18	197	20 34 60+		00000000104

Figure A-2. Example check_records.dat file.

Table A-2. Description of records in check_records.dat file.

Record number*	Non-zero flags	Situation	Possible solution
1	3, 8, and 9	4-character string in columns 30-113; no numbers in columns 87-89; number in column 90	Do not use record; 4-character string appears to be a time
2-6	3	4-character string in columns 30-113	Eliminate characters after column 92
7	9	number in column 90	Shift data from 90 to 113 left one column and eliminate columns beginning with "34"

*actual line number in file is record number plus one.

Once any records have been changed, the user can rename good_records.dat and check_records.dat, enter the new filenames in inputfiles.txt in place of the original data, and AERMINUTE can be rerun with the original good records and updated records from check_records.dat.

Example records from bad_records.dat are shown in Figure A-3. As with the previous examples, certain column numbers are denoted. In the first record, the record fails the quality control check because there are non-numeric characters in columns 68 through 90, and no numeric characters in columns 70-74, 76-79, 82-84, and 87-89. Other records shown in Figure A-3 fail the quality control checks because flag 1 is triggered, non-numeric characters in columns 67-90 and no numeric characters in columns 70-74 or 76-79. These are missing wind fields as denoted by the letter "M."

30		68-73	75-78	81-83	86-89	
		123456	1234	123	1234	
13740KRIC RIC2005011110381538	M M	M	M	M	M	34 60+	10001111000
13740KRIC RIC2005011110391539	M M	M	M	60	7	34 60+	10001100000
13740KRIC RIC2005011110401540	0.216 D	M	M	128	7	34 60+	10001100000

Figure A-3. Example bad_records.dat file

Record checking of 5-minute data is more straightforward than record checking of 1-minute data as the 5-minute data files are in a more consistent format than the 1-minute files. When processing the 5-minute files, AERMINUTE performs the following checks:

- The record is checked for the presence of the text string "5-MIN" and if not present the record is no longer processed
- The record is checked for the presence of the text string "AUTO" which sets the columns in which to search for the wind data. If "AUTO" is not present, then the wind data are determined in columns 67 through 73 of the record. If "AUTO" is present, then the wind data are determined in columns 72 through 78.
- In the text string containing the wind data, the string "KT" for knots is searched. If this is not found, this is not necessarily a bad record, because the letter "G" for gust may be in the string. If "KT" is not found and "G" is not subsequently found, the record is no longer processed.
- If "KT" or "G" are found in the wind data columns, the first five columns of the wind data columns are searched for non-numeric characters. If non-numeric characters are found, then the record is no longer processed.
- If the first five columns of the wind data columns are numeric, the first two columns are read in as the wind direction as tens of degrees and the remaining three columns are read in as the wind speed in knots. The wind direction is checked to make sure it is between 0 and 36 (for 360) and the wind speed is between 0 and 50 knots. If these checks are passed the winds are considered valid.

Appendix B. ASOS stations missing 1-minute data files for June-December 2013

Tables B-1 through B-10 list the stations, by EPA region, missing 1-minute data for June-December 2013. Figures B-1 and B-2 show the locations of the stations in the continental U.S. and Alaska, respectively.

Table B-1. Region 1 ASOS stations.

Station	Station Name	State
KIJD	WILLIMANTIC WINDHAM AP	CT
KAQW	NORTH ADAMS HARRIMAN AP	MA
KCQX	CHATHAM MUNI AP	MA
KFIT	FITCHBURG MUNI AP	MA
KORE	ORANGE MUNI AP	MA
KPSF	PITTSFIELD MUNI AP	MA
KPYM	PLYMOUTH MUNI AP	MA
KTAN	TAUNTON MUNI AP	MA
KCAR	CARIBOU WFO	ME
KFVE	FRENCHVILLE AROOSTOOK AP	ME
KHUL	HOULTON AP	ME
KMLT	MILLINOCKET MUNI AP	ME
KAFN	JAFFREY MUNI AP	NH
KCON	CONCORD ASOS	NH
KUUU	NEWPORT STATE AP	RI
KWST	WESTERLY STATE AP	RI
KDDH	BENNINGTON MORSE ST AP	VT
KMPV	MONTPELIER AP	VT
KMVL	MORRISVILLE STOWE STATE AP	VT
KVSF	SPRINGFIELD HARTNESS AP	VT

Table B-2. Region 2 ASOS stations.

Station	Station Name	State
K12N	ANDOVER AEROFLEX AP	NJ
KART	WATERTOWN AP	NY
KDKK	DUNKIRK CHAUTAUQUA AP	NY
KDSV	DANSVILLE AP	NY
KELZ	WELLSVILLE MUNI AP	NY
KFZY	FULTON OSWEGO CO AP	NY
KGFL	GLENS FALLS AP	NY
KMSS	MASSENA AP	NY
KMTP	MONTAUK AP	NY
KNYC	NEW YORK CNTRL PRK WSF	NY
KPBG	PLATTSBURGH AFB	NY
KPEO	PENN YAN AP	NY
KRME	GRIFFISS AFB	NY
KSLK	SARANAC RGNL AP	NY

Table B-3. Region 3 ASOS stations.

Station	Station Name	State
KOXB	OCEAN CITY MUNI AP	MD
KAOO	ALTOONA BLAIR CO AP	PA
KBFD	BRADFORD FAA AP	PA
KFIG	CLEARFIELD LAWRENCE AP	PA
KGKJ	PORT MEADVILLE AP	PA
KAKQ	NORFOLK RICH	VA
KOFP	ASHLAND HANOVER CO MUNI AP	VA
KBKW	BECKLEY RALEIGH CO AP	WV
KEKN	ELKINS RANDOLPH COUNTY AP	WV

Table B-4. Region 4 ASOS stations.

Station	Station Name	State
KANB	ANNISTON ARPT ASOS	AL
KDCU	DECATUR PRYOR FLD	AL
KEET	ALABASTER 5 SSE	AL
KMSL	MUSCLE SHOALS AP	AL
KTOI	TROY AF	AL
K40J	PERRY FOLEY AP	FL
KAAF	APALACHICOLA AP	FL
KCTY	CROSS CITY AP	FL
KMTH	MARATHON AP	FL
KAMG	ALMA BACON CO AP	GA
KDNL	AUGUSTA DANIEL FLD	GA
KFFC	ATLANTA	GA
KGVL	GAINESVILLE GILMER AP	GA
KRMG	ROME R B RUSSELL AP	GA
KSSI	BRUNSWICK CAA AP	GA
KVPC	CARTERSVILLE AP	GA
KJKL	JACKSON	KY
KGWO	GREENWOOD FAA AP	MS
KECG	ELIZABETH CITY CG STN	NC
KHSE	CAPE HATTERAS AP	NC
KCUB	COLUMBIA OWENS DWTN AP	SC
KOGB	ORANGEBURG MUNI AP	SC

Table B-5. Region 5 ASOS stations.

Station	Station Name	State
KADG	ADRIAN LENAWEE CO AP	MI
KANJ	SAULT STE MARIE SNDRSN	MI
KAPN	ALPENA AP	MI
KGLR	GAYLORD OTSEGO CO AP	MI
KHTL	HOUGHTON LAKE WSO AP	MI
KPLN	PELLSTON AP	MI
KBDE	BAUDETTE INTL AP	MN
KBRD	BRAINERD CROW WING CO AP	MN
KHIB	HIBBING CHISHOLM HIBBING A	MN
KINL	INTERNATIONAL FALLS AP	MN
KPKD	PARK RAPIDS 2 S	MN
KAKR	AKRON FULTON INTL AP	OH
KBJJ	WOOSTER WAYNE CO AP	OH
KFDY	FINDLAY AP	OH
KHZY	ASHTABULA CO AP	OH
KILN	CINCINNATI	OH
KLPR	ELYRIA LORAIN CO AP	OH
KMNN	MARION MUNI AP	OH
KTDZ	TOLEDO METCALF FLD	OH
KASX	ASHLAND KENNEDY MEM AP	WI
KAUW	WAUSAU ASOS	WI
KHYR	HAYWARD MUNI AP	WI
KISW	WISCONSIN RAPIDS ALEXANDER	WI
KOVS	BOSCOBEL AP	WI

Table B-6. Region 6 ASOS stations.

Station	Station Name	State
KESF	ALEXANDRIA ESLER FLD	LA
KTVR	TALLULAH VICKSBURG AP	LA
KCAO	CLAYTON MUNI ARPK AP	NM
KDMN	DEMING FAA AP	NM
KGUP	GALLUP FAA AP	NM
KLVS	LAS VEGAS FAA AP	NM
KRTN	RATON MUNI CREWS AP	NM
KTCC	TUCUMCARI FAA AP	NM
KTCS	TRUTH OR CONSEQUENCE AP	NM
KGUY	GUYMON MUNI AP	OK
K6R6	DRYDEN TERRELL CO AP	TX
KALI	ALICE CAA AP	TX
KBAZ	NEW BRAUNFELS AP	TX
KBGD	BORGER HUTCHINSON CO AP	TX
KBMQ	BURNET AP	TX
KCOT	COTULLA	TX
KCRS	CORSICANA CAMPBELL FLD	TX
KCXO	CONROE MONTGOMERY CO AP	TX
KDHT	DALHART FAA AP	TX
KDRT	DEL RIO AP	TX
KHDO	HONDO AP	TX
KJCT	JUNCTION	TX
KLBX	ANGLETON BRAZORIA AP	TX
KLVJ	HOUSTON CLOVER FLD	TX
KMWL	MINERAL WELLS AP	TX
KPIL	PORT ISABEL CAMERON AP	TX
KPSX	PALACIOS FAA AP	TX
KRKP	ROCKPORT ASOS	TX
KTRL	TERRELL MUNI AP	TX
KUTS	HUNTSVILLE MUNI AP	TX
KVCT	VICTORIA ASOS	TX

Table B-7. Region 7 ASOS stations.

Station	Station Name	State
KAMW	AMES MUNI AP	IA
KBRL	BURLINGTON AP	IA
KDVN	DAVENPORT	IA
KEST	ESTHERVILLE MUNI AP	IA
KIOW	IOWA CITY CAA AP	IA
KLWD	LAMONI MUNI AP	IA
KMCW	MASON CITY AP	IA
KMIW	MARSHALLTOWN MUNI AP	IA
KOTM	OTTUMWA AP	IA
KSPW	SPENCER MUNI AP	IA
KCNK	CONCORDIA ASOS	KS
KDDC	DODGE CITY	KS
KGLD	GOODLAND	KS
KHLC	HILL CITY 1 NE	KS
KDMO	SEDALIA MEM AP	MO
KIRK	KIRKSVILLE RGNL AP	MO
KLXT	LEES SUMMIT MUNI AP	MO
KPOF	POPLAR BLUFF MUNI AP	MO
KAIA	ALLIANCE MUNI AP	NE
KBFF	SCOTTSBLUFF AP	NE
KCDR	CHADRON FAA AP	NE
KHSI	HASTINGS MUNI AP	NE
KLBF	NORTH PLATTE RGNL AP	NE
KMCK	MCCOOK MUNI AP	NE
KODX	EVELYN SHARP FIELD	NE
KOFK	NORFOLK	NE
KSNY	SIDNEY 3 S	NE
KVTN	VALENTINE MILLER AP	NE

Table B-8. Region 8 ASOS stations.

Station	Station Name	State
KAKO	AKRON 1 N	CO
KALS	ALAMOSA BERGMAN FLD	CO
KCAG	CRAIG ASOS	CO
KCEZ	CORTEZ ASOS	CO
KDRO	DURANGO ASOS	CO
KEEO	MEEKER AP	CO
KITR	BURLINGTON CARSON AP	CO
KLIC	LIMON WSMO	CO
KLXV	LEADVILLE 2 SW	CO
KMTJ	MONTROSE ASOS	CO
KBHK	BAKER MUNI AP	MT
KBTM	BUTTE BERT MOONEY AP	MT
KGGW	GLASGOW	MT
KHVR	HAVRE AP ASOS	MT
KJDN	JORDAN AP	MT
KLVM	LIVINGSTON AP	MT
KMLS	MILES CITY AP	MT
KOLF	WOLF POINT INTL AP	MT
KDIK	DICKINSON FAA AP	ND
KHEI	HETTINGER MUNI AP	ND
KISN	WILLISTON SLOULIN FLD	ND
KJMS	JAMESTOWN FAA AP	ND
K8D3	SISSETON MUNI AP	SD
K9V9	CHAMBERLAIN MUNI AP	SD
KABR	ABERDEEN	SD
KATY	WATERTOWN FAA AP	SD
KCUT	CUSTER CO AP	SD
KD07	FAITH MUNI AP	SD
KHON	HURON AP	SD
KMBG	MOBRIDGE MUNI AP	SD
KMHE	MITCHELL AP	SD
KPHP	PHILIP 2 N	SD
KPIR	PIERRE FAA AP	SD
KCNY	CANYONLANDS ASOS	UT
KMLF	MILFORD MUNI AP	UT
KVEL	VERNAL AP	UT
KDGW	CONVERSE CO AP ASOS	WY
KGCC	GILLETTE CAMPBELL AP	WY
KLAR	LARAMIE AP	WY

Table B-8. Continued.

Station	Station Name	State
KLND	LANDER AP	WY
KP60	YELLOWSTONE LAKE	WY
KRIW	RIVERTON	WY
KRWL	RAWLINS AP	WY
KSHR	SHERIDAN AP	WY
KTOR	TORRINGTON MUNI AP	WY

Table B-9. Region 9 ASOS stations.

Station	Station Name	State
KIGM	KINGMAN AP	AZ
KINW	WINSLOW AP	AZ
KPGA	PAGE MUNI AP	AZ
KRQE	WINDOW ROCK AP	AZ
KSAD	SAFFORD MUNI AP	AZ
KSJN	ST JOHNS INDUSTRIAL AP	AZ
KAAT	ALTURAS MUNI AP	CA
KACV	ARCATA AP	CA
KAVX	AVALON CATALINA AP	CA
KBIH	BISHOP AP	CA
KBLU	BLUE CANYON	CA
KCEC	CRESCENT CITY CAA AP	CA
KHJO	HANFORD MUNI AP	CA
KMAE	MADERA MUNI AP	CA
KMCE	MERCED MUNI AP	CA
KPRB	PASO ROBLES CAA AP	CA
KRBL	RED BLUFF	CA
KSIY	MONTAGUE	CA
KUKI	UKIAH FAA AP	CA
KWVI	WATSONVILLE MUNI AP	CA
KELY	ELY AIRPORT	NV
KWMC	WINNEMUCCA AP	NV

Table B-10. Region 10 ASOS stations.

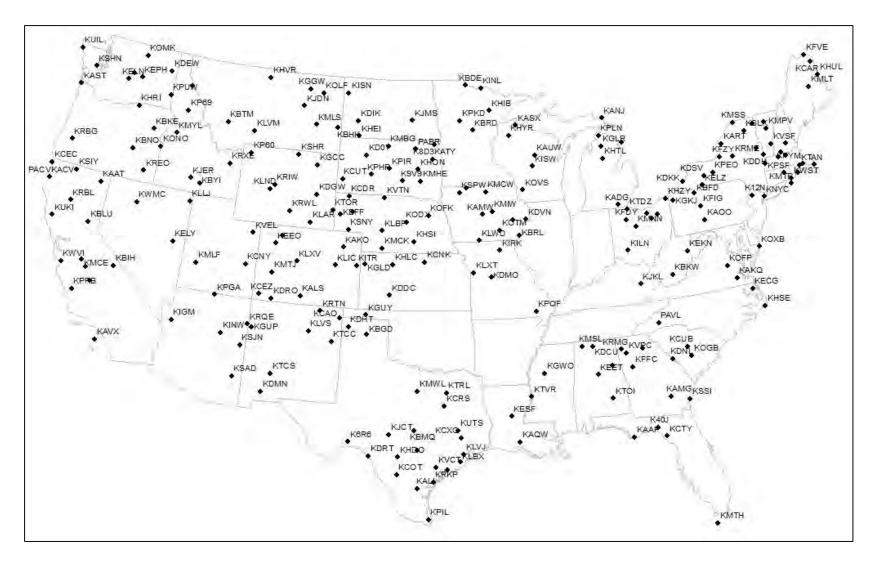| Station	Station Name	State
PABR	BARROW WSO AP	AK
PACD	COLD BAY AP	AK
PACV	CORDOVA AP	AK
PADE	DEERING AP	AK
PAGK	GULKANA AP	AK
PAMC	MCGRATH AP	AK
PANN	NENANA MUNI AP	AK
PANT	ANNETTE WSO AP	AK
PAPB	ST GEORGE ISLAND AP	AK
PAQT	NUIQSUT AP	AK
PASN	ST PAUL ISLAND AP	AK
PASO	SELDOVIA AP	AK
PATO	PORTAGE GLACIER V C	AK
PAVL	KIVALINA AP	AK
PAWD	SEWARD	AK
PAYA	YAKUTAT AP	AK
KBYI	BURLEY FAA AP	ID
KJER	JEROME CO AP	ID
KLLJ	CHALLIS AP	ID
KMLP	MULLAN PASS VOR/DME	ID
KMYL	MCCALL AP	ID
KP69	LOWELL THREE RIVERS	ID
KRXE	REXBURG MADISON CO AP	ID
KAST	ASTORIA AP PORT OF	OR
KBKE	BAKER CAA AP	OR
KBNO	BURNS MUNI AP	OR
KHRI	HERMISTON MUNI AP	OR
KONO	ONTARIO	OR
KRBG	ROSEBURG RGNL AP	OR
KREO	ROME ST AP	OR
KDEW	DEER PARK	WA
KEAT	WENATCHEE AP	WA
KELN	ELLENSBURG BOWERS FLD	WA
KEPH	EPHRATA AP	WA
KOMK	OMAK	WA
KPUW	PULLMAN MOSCOW RGNL AP	WA
KSHN	SHELTON AP	WA
KUIL	QUILLAYUTE AP	WA

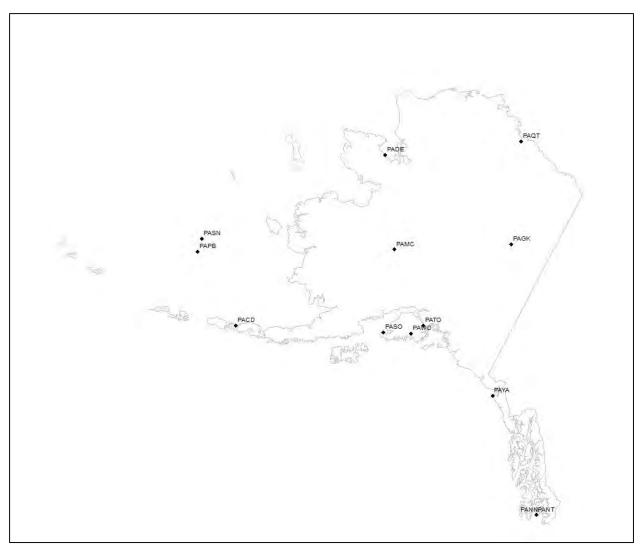**Figure B-1. Locations of ASOS stations in conterminous U.S. with missing June-December 2013 1-minute data files.**

Figure B-2. Locations of ASOS stations in Alaska with missing June-December 2013 1-minute data files.